

TITLE OF THE INVENTION

ELECTRONIC APPARATUS WITH COMMUNICATION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application is based upon and claims the  
benefit of priority from prior Japanese Patent  
Application No. 2003-057368, filed March 4, 2003,  
the entire contents of which are incorporated herein  
by reference.

BACKGROUND OF THE INVENTION

10 1. Field of the Invention

The present invention relates to an electronic  
apparatus capable of transmitting content data to  
an external device.

2. Description of the Related Art

15 In recent years, attention has been paid to  
Bluetooth™ as a wireless communication technology.  
Bluetooth™ is a low-cost, low-power-consumption,  
short-range wireless communication technology suitable  
for mobile devices. Bluetooth™ is used for mutual  
20 connection of various mobile information devices owned  
by individual users. The devices are wirelessly  
connected and, compared to conventional connection by  
wire, the devices can be connected more freely, simply  
and easily.

25 Jpn. Pat. Appln. KOKAI Publication No. 2002-112383  
discloses a system wherein music data is transmitted  
from an electronic device such as a music player to

headphones by means of radio signals.

In this system, however, no consideration is given to communication with a headset including a speaker and a microphone.

5           The headset including a speaker and a microphone is usable not only for music reproduction but also for, e.g. a conversation ("interaction") with a computer. In order to perform a conversation, transmission of audio data from the headset to the computer, as well  
10 as transmission of audio data from the computer to the headset, is required. Normally, the required quality of audio data for music reproduction differs from that for conversation.

          As stated above, a necessary communication  
15 environment for the headset differs between the use for music reproduction and the use for conversation. In order to change the communication environment, however, various parameters have to be individually set and the operation for the setting is very difficult for  
20 the user.

#### BRIEF SUMMARY OF THE INVENTION

          According to an embodiment of the present invention, there is provided an electronic apparatus comprising: a communication device that executes  
25 communication with an external device; an input device; means for selecting one of a first communication mode and a second communication mode in accordance with

an operation of the input device; and means for, when the first communication mode is selected, controlling one-way communication to transmit content data from the communication device to the external device with a first quality and for, when the second communication mode is selected, controlling two-way communication to transmit and receive content data between the communication device and the external device with a second quality which is lower than the first quality.

10 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

FIG. 1 shows an external appearance of a computer according to an embodiment of the present invention;

FIG. 2 shows an example of a communication mode select screen displayed on the computer of FIG. 1;

FIG. 3 illustrates a connection establishing process in an audio mode used in the computer of FIG. 1;

FIG. 4 illustrates a connection establishing process in a conversation mode used in the computer of FIG. 1;

FIG. 5 is a table for explaining the direction of

streaming and the kind of CODEC in each of the audio mode illustrated in FIG. 3 and the conversation mode illustrated in FIG. 4;

FIG. 6 is a block diagram showing the system configuration of the computer of FIG. 1;

FIG. 7 is a block diagram showing the software scheme of the computer of FIG. 1;

FIG. 8 is a block diagram showing a system configuration of a headset that is wirelessly connected to the computer of FIG. 1; and

FIG. 9 is a flow chart illustrating the procedure of a communication control process that is executed by the computer of FIG. 1.

#### DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the present invention will now be described with reference to the accompanying drawings.

FIG. 1 shows the external appearance of an electronic apparatus 10 according to an embodiment of the invention. The electronic apparatus 10 is configured to be able to transmit a stream of content data such as music to an external device 20 by radio signals. In this embodiment, the electronic apparatus 10 is realized as a notebook-type personal computer, and the external device 20 is realized as a wireless headset.

The personal computer 10 is a portable information processing apparatus that can be powered by a battery.

The personal computer 10 comprises a computer main body 11 and a display unit 12. A display device composed of an LCD (Liquid Crystal Display) 121 is built in the display unit 12. The LCD 121 is positioned at a substantially central area of the display unit 12.

The display unit 12 is attached to be rotatable between an open position and a closed position relative to the computer main body 11. The computer main body 11 has a thin box-shaped casing. A keyboard 13, a power button 14 for switching on/off the computer 10, a touch pad (pointing device) 15, etc. are disposed on the upper surface of the computer main body 11.

A wireless communication device is built in the computer main body 11. The wireless communication device enables the computer 10 to perform communication with the headset 20. The wireless communication device is configured to execute wireless communication according to Bluetooth™ standards.

A wireless utility program that is a program for controlling wireless communication with the headset 20 is installed in the computer 10. The wireless utility program controls communication between the computer 10 and headset 20. The wireless utility program has two communication modes for the communication with the headset 20, as is described below.

One is a communication mode (hereinafter referred to as "audio mode") for transmitting audio data such as

music with high quality. The other is a communication mode (hereinafter "conversation mode") for transmitting and receiving audio data between the headset 20 and computer 10 with a quality of a voice call level ("speech quality").

The audio mode, which places importance on the quality of audio data, is a communication mode suited to the case where a user listens to audio data such as music sent from the computer 10, by using the headset 20. The conversation mode, which permits transmission and reception of audio data with a conversation quality, is a communication mode suited to, for example, the case where the user conducts an electronic conference via the computer 10 with terminals on the Internet, or the case where the user operates a voice recognition/synthesis program, which is executed on the computer 10, by using the headset 20.

In Bluetooth™, Advanced Audio Distribution Profile (A2DP) is specified as a profile relating to transmission of audio data. A2DP is a function for transmitting audio data such as music with high quality. In A2DP, an asynchronous data channel called ACL (Asynchronous Connectionless) is utilized.

Both the audio mode and the conversation mode may be realized by making use of A2DP.

When the wireless utility is activated, a mode select window 30 is displayed on the display screen of

the LCD 121. The mode select window 30 is used to prompt the user to select one of the audio mode (mode 1) and the conversation mode (mode 2). In this case, an input device such as the keyboard 13 or touch pad 15 functions as a user interface unit. In accordance with the user's operation on the input device, the audio mode or the conversation mode is selected for communication with the headset 20.

When the audio mode is selected, the wireless utility program executes one-way communication for transmitting an audio data stream such as music with high quality from the computer 10 to the headset 20. In this case, a channel for transmitting the audio data stream from the computer 10 to the headset 20 is established, and one-way communication is executed via the channel.

The "one-way," in this context, means that the direction of transmission of the audio data stream is limited to the direction from the computer 10 to the headset 20. For example, control data such as acknowledgement (ACK), is sent from the headset 20 to the computer 10.

When the conversation mode is selected, the wireless utility program executes two-way communication for transmitting and receiving an audio data stream such as voice with conversation quality between the computer 10 and the headset 20. In this case, two

independent channels are established between the computer 10 and headset 20. One channel is used to transmit an audio data stream with conversation quality from the computer 10 to the headset 20, and the other  
5 channel is used to transmit an audio data stream with conversation quality from the headset 20 to the computer 10.

The bandwidth of each channel established in the conversation mode is narrower than that of the channel  
10 established in the audio mode. In the conversation mode, the transmission quality of audio data is made lower than that in the audio mode, so two-way communication with a higher throughput can be executed.

The headset 20 is an output device for reproducing  
15 audio data such as music and voice, which is sent by radio from the computer 10, thereby producing sound corresponding to the audio data. The headset 20 includes a microphone 205. The user's voice signal input through the microphone 205 can be transmitted to  
20 the computer 10 by radio.

The headset 20 is configured to be wearable on the head of the user. The headset 20, as shown in FIG. 1, comprises a head arm 201, and two ear pads 202 and 203 provided at both ends of the head arm 201. Each ear  
25 pad 202, 203 incorporates a speaker. Each ear pad 202, 203 functions as a speaker unit.

In the state in which the headset 20 is worn on



the head of the user, the two ear pads 202 and 203 cover the right and left ears of the user. One end of a microphone arm 204 is attached to the pad 202, and the other end thereof is provided with the microphone 205.

FIG. 2 shows a concrete example of the mode select window 30 presented by the wireless utility program.

The mode select window 30, as shown in FIG. 2, displays two icons 31 and 32 corresponding to the audio mode and conversation mode. The user clicks the icon 31 or icon 32 by operating the input device such as the keyboard 13 or touch pad 15.

Specifically, when the user has double-clicked the icon 31, the wireless utility program establishes connection between the computer 10 and headset 20 in the audio mode. When the user has double-clicked the icon 32, the wireless utility program establishes connection between the computer 10 and headset 20 in the conversation mode.

FIG. 3 illustrates a connection establishing process in the audio mode.

The wireless utility program controls a wireless communication device included in the computer 10, thereby starting the connection establishing process. In the connection establishing process, a procedure is executed for establishing one-way channel (transport channel) for transmitting audio data such as music from

the computer 10 to the headset 20 with high quality.

In the connection establishing process, the wireless utility program executes negotiation with the headset 20 and sets communication conditions relating to audio transmission in both the computer 10 and headset 20, which are to function as stream end points of the transport channel.

The computer 10 functions as a source device for transmitting audio data via the established transport channel. The headset 20 functions as a sink device for receiving audio data that is transmitted via the established transport channel.

The setting of communication conditions is executed using parameter information that is preset according to the audio mode. The parameter information includes various parameter values such as the kind of CODEC (Compression/DECompression) to be applied to audio data that is to be transmitted, and the value of sampling frequency used in CODEC.

The parameter indicative of the kind of CODEC designates a compression-encoding scheme by which audio data to be transmitted is compressed and encoded. The value of sampling frequency designates a sampling frequency to be used in an encoder provided in the computer 10 and in a decoder provided in the headset 20.

Following the connection establishing process,

a process (streaming) for transmitting audio data from the computer 10 to the headset 20 is started.

FIG. 4 illustrates a connection establishing process in the conversation mode.

5           The wireless utility program controls the wireless communication device included in the computer 10, thereby starting the connection establishing process. In the connection establishing process, a procedure is executed for establishing two transport channels for  
10           bidirectionally transferring audio data such as voice signals between the computer 10 and the headset 20.

          In the connection establishing process, the wireless utility program executes negotiation with the headset 20 and sets, for the respective transport  
15           channels, communication conditions relating to audio transmission in both the computer 10 and headset 20 that are to function as stream end points of each of the transport channels.

          As regards one of the two transport channels,  
20           the computer 10 functions as a source device for transmitting audio data via the transport channel, and the headset 20 functions as a sink device for receiving audio data that is transmitted via this transport channel. As regards the other transport channel,  
25           the headset 20 functions as a source device and the computer 10 functions as a sink device.

          The setting of communication conditions is

executed using parameter information that is preset according to the conversation mode. The parameter information includes various parameter values such as the kind of CODEC (Compression/DECompression) to be applied to audio data that is to be transmitted, and the value of sampling frequency used in CODEC.

Following the connection establishing process, a process for transmitting audio data from the computer 10 to the headset 20 and a process for transmitting audio data from the headset 20 to the computer 10 can simultaneously be executed.

FIG. 5 shows the direction of streaming and the kind of CODEC in each of the audio mode and conversation mode.

In the audio mode, transmission of an audio data stream is executed only in one direction and the kind of CODEC used in the streaming is, e.g. low-compression SBC (Subband Codec). SBC is a compression-encoding/decoding scheme for music data, and a relatively large amount of arithmetic operations are needed for the processing of SBC. SBC, however, realizes sound reproduction with a sufficiently high quality on the receiving side. In the audio mode, the microphone 205 is not used, so no audio data is transmitted from the headset 20 to the computer 10. Thus, even if SBC that requires a large amount of arithmetic operations is used, the headset 20 can decode and reproduce in real

time a stream of audio data such as music that is received from the computer 10.

In the conversation mode, two-way transmission of audio data streams is executed. The kind of CODEC used in the streaming in each direction is a compression-  
5 encoding scheme for voice signals, such as  $\mu$ -law. Compared to SBC,  $\mu$ -law requires a less amount of arithmetic operations. Therefore, the headset 20 can decode and reproduce in real time a stream of audio  
10 data such as voice signals that are received from the computer 10, and at the same time it can compression-encodes a voice signal input from the microphone 205 and transmit in real time the compression-encoded voice signal to the computer 10.

15 The system configuration of the computer 10 will now be described with reference to FIG. 6.

The computer 10, as shown in FIG. 6, comprises a CPU 101, a host bridge 102, a main memory 103, a display controller 104, a system controller 105, a hard  
20 disk drive (HDD) 106, a wireless communication device 107, a sound controller 109, an audio amplifier 110, a speaker 111, a BIOS-ROM 112, and an embedded controller/keyboard controller IC (EC/KBC) 113.

The CPU 101 is a processor provided to control the  
25 operations of the computer 10. The CPU 101 executes an operating system (OS) 301 and various application/utility programs loaded in the main memory 103 from

the hard disk drive (HDD) 106. The CPU 101 also executes a BIOS (Basic Input/Output System) stored in the BIOS-ROM 112.

5 In the computer 10, a wireless utility program 302 is pre-installed as one of utility programs. The wireless utility program 302 controls communication between the wireless communication device 107 and the headset 20 in the audio mode or in the conversation mode.

10 The host bridge 102 is a bridge device that connects the local bus of the CPU 101 and the system controller 105. The host bridge 102 includes a memory controller that controls access to the main memory 103. The display controller 104 controls the LCD 121 used as  
15 a display monitor of the computer 1.

The system controller 105 controls each device on a PCI (Peripheral Component Interconnect) bus 1 and each device on an ISA (Industry Standard Architecture) bus 2. The system controller 105 includes an IDE  
20 (Integrated Drive Electronics) controller for controlling the HDD 106. The system controller 105 also includes a USB (Universal Serial Bus) controller 200. The wireless communication device 107 is connected to the USB controller 200.

25 The wireless communication device 107 is a device for executing wireless communication and includes a baseband unit and an RF (Radio Frequency) unit. The RF

unit performs transmission/reception of a radio signal via an antenna (ANT) 108. The wireless communication device 107 is configured to execute wireless communication according to Bluetooth™ standards.

5           The sound controller 109 is a device for reproducing audio data. An audio signal output from the sound controller 109 is delivered to the speaker 111 via the audio amplifier (AMP) 110. The speaker 111 produces the audio signal as sound.

10           The embedded controller/keyboard controller IC (EC/KBC) 113 is a one-chip microcomputer in which an embedded controller for power management and a keyboard controller for controlling the keyboard (KB) 13 and touch pad 15 are integrated. The keyboard (KB) 13 and touch pad 15 are user interface units that can  
15           be operated by the user. The keyboard (KB) 13 and touch pad 15 are used for inputting various data and selecting the communication mode. In addition, the embedded controller/keyboard controller IC (EC/KBC) 113  
20           has a function of powering on/off the computer 10 in accordance with the operation of the power button 14 by the user.

          The scheme of software for controlling the wireless communication device 107 is described  
25           referring to FIG. 7.

          The wireless communication device 107 comprises a hardware logic (baseband unit 504, RF unit 505)

and firmware for controlling the hardware logic.

The firmware includes a physical BUS driver 501, an HCI (Host Control Interface) firmware 502, and an LMP (Link Management Protocol) 503. The BUS driver 501 is a driver for connecting the wireless communication device 107 to a bus such as a USB. The HCI firmware 502 is a driver for communication with the host (computer 10) via the BUS driver 501. The LMP 503 is a driver for controlling a physical wireless link.

As programs for controlling the wireless communication device 107, protocol drivers 307 that constitute a protocol stack, as well as the aforementioned wireless utility program 302, are installed in the computer 10.

The protocol drivers 307 include a higher layer driver 401 for executing an A2DP function, an HCI driver 402 for executing communication with the wireless communication device 107, and a physical BUS driver 403 for controlling the bus such as a USB, to which the wireless communication device 107 is connected.

The wireless utility program 302 controls the wireless communication device 107 via the protocol drivers 307, thereby controlling transfer of an audio data stream between the headset 20 and computer 10. In the connection establishing process for this streaming, the wireless utility program 302 establishes



a transport channel between the headset 20 and computer 10 in accordance with the content of an environment setting information file 306. The environment setting information file 306 prestores parameter information for the audio mode and parameter information for the conversation mode.

Audio data reproduced by various application programs 303 is delivered to a first sound driver 304 or a second sound driver 305 via the OS 301. The first sound driver 304 is a driver for controlling the sound controller 109. The first sound driver 304 is used to produce sound from the built-in speaker 111 via the sound controller 109. The second sound driver 305 is a driver for transmitting audio data to the wireless communication device 107 via the protocol drivers 307.

The wireless utility program 302 loads the second sound driver 305 in the main memory 103, thereby to send audio data to the headset 20 by radio. The second sound driver 305 has a higher priority than the first sound driver 304. After the second sound driver 305 is loaded, the second sound driver 305, in place of the first sound driver 304, is used by the OS 301. Accordingly, all audio data reproduced by the application programs 303 and OS 302 is sent to the second sound driver 305.

The second sound driver 305 has a CODEC associated with both SBC and  $\mu$ -law. The second sound driver

305 compression-encodes transmission data by using a  
compression-encoding scheme designated by the wireless  
utility program 302. The value of sampling frequency  
used in the compression-encoding process is also  
5 designated by the wireless utility program 302.

Referring now to FIG. 8, the system configuration  
of the headset 20 is described.

The headset 20, as shown in FIG. 8, comprises a  
wireless communication device 701, a system controller  
10 702, an audio reproducing unit 703, and an audio input  
unit 704.

The system controller 702 is a processor provided  
to control the operations of the headset 20. The  
system controller 702 controls the wireless communica-  
15 tion device 701, audio reproducing unit 703 and  
audio input unit 704. The system controller 702 has  
a "source" function of the aforementioned A2DP and  
a "sink" function of the A2DP. The system controller  
702 includes a CODEC 801 associated with both SBC and  
20  $\mu$ -law.

The wireless communication device 701, like the  
wireless communication device 107 of computer 10,  
executes wireless communication on the basis of  
a procedure according to Bluetooth™ standards.

25 The audio reproducing unit 703 executes a data  
reproduction process for streaming reproduction.  
That is, in this process, while receiving an audio

data stream sent from the computer 10 via the wireless communication device 701 and system controller 702, the audio reproducing unit 703 converts the audio data stream to an electric signal that can be output as  
5 sound from the speaker 801 built in each pad 202, 203. The audio input unit 704 converts an analog voice signal input from the microphone 205 to a digital signal, and delivers it to the system controller 702.

Next, referring to a flow chart of FIG. 9,  
10 a communication control process that is executed by the wireless utility program 302 is described.

As has been described above, when the wireless utility program 302 is activated, the mode select window shown in FIG. 2 is displayed on the LCD 121.  
15 If the icon 31 or 32 on the mode select window 30 is double-clicked by the user's operation on the keyboard 13 or touch pad 15 (YES in step S101), the wireless utility program 302 selects one of the audio mode and conversation mode in accordance with the double-clicked  
20 icon 31 or 32 (step S102).

If the audio mode is selected, the wireless utility program 302 sets the number of transport channels to be established to be 1 (step S103). The wireless utility program 302 performs environment  
25 setting for the transport channel, thereby establishing the transport channel for transmitting an audio stream from the computer 10 to the headset 20 (step S104).

In step S104, the wireless utility program 302 executes negotiation with the headset 20 in accordance with the audio mode parameter information stored in the environment setting information file 306, and sets  
5 communication conditions (value of sampling frequency, kind of CODEC, etc.) in the computer 10 (wireless communication device 107) and headset 20 (wireless communication device 701) functioning as stream end points. The setting of the communication conditions is  
10 executed via a control channel established between the computer 10 and headset 20.

The role of the sink (SNK) device is assigned to the remote device, that is, the headset 20. The role of the source (SRC) device is assigned to the local  
15 device, that is, the computer 10.

The processing in step S104 establishes the one-way transport channel that is configured to transmit with high quality the audio data such as music from the computer 10 to the headset 20. CODEC is SBC, and  
20 the value of sampling frequency used in the SBC is sufficiently high. Consequently, the established transport channel has a sufficient bandwidth suited for high-quality transmission.

Then, the wireless utility program 302 loads the  
25 second sound driver 305 (step S107), and informs the headset 20 of the start of streaming, thus executing a streaming process (step S108). In step S108, a stream

of audio data such as music is transmitted from the computer 10 to the headset 20.

On the other hand, when the conversation mode is selected, the wireless utility program 302 sets the number of transport channels to be established to be 2 (step S105). The wireless utility program 302 performs environment setting for each of the two transport channels, thereby establishing the transport channel (channel #1) configured to transmit an audio stream from the computer 10 to the headset 20 with conversation quality and the transport channel (channel #2) configured to transmit an audio stream from the headset 20 to the computer 10 with conversation quality (step S106).

In step S106, the wireless utility program 302 executes negotiation with the headset 20 in accordance with the conversation mode parameter information stored in the environment setting information file 306, and sets communication conditions (value of sampling frequency, kind of CODEC, etc.) in the computer 10 (wireless communication device 107) and headset 20 (wireless communication device 701) functioning as stream end points. The setting of the communication conditions is individually executed for each of the transport channels.

As regards the channel #1, the role of the sink (SNK) device is assigned to the remote device, that is,

the headset 20, and the role of the source (SRC) device is assigned to the local device, that is, the computer 10. On the other hand, as regards the channel #2, the role of the sink (SNK) device is assigned to the local device, that is, the computer 10, and the role of the source (SRC) device is assigned to the remote device, that is, the headset 20.

The CODEC for each channel is  $\mu$ -law, and the value of sampling frequency used in the  $\mu$ -law is relatively low. Consequently, each of the established transport channels has a narrower bandwidth than the bandwidth of the transport channel established in the audio mode. In other words, in the conversation mode, the low sampling frequency and  $\mu$ -law are used, and thus the quality of audio data becomes lower than that in the audio mode. However, the load on CODEC becomes lower and two-way communication with a higher throughput is realized.

Then, the wireless utility program 302 loads the second sound driver 305 (step S107), and informs the headset 20 of the start of streaming, thus executing a streaming process (step S108). In step S108, the use of the two transport channels enables simultaneous transmission of audio data from the computer 10 to headset 20 and from the headset 20 to computer 10.

According to the present embodiment, as described above, simple clicking of the icon on the display

screen can effect switching between the two communication modes, i.e. the audio mode and conversation mode. Thereby, wireless communication environments suited for music reproduction and conversation (two-way  
5 communication) can be configured. Specifically, in the audio mode, content data is transmitted with high quality. In the conversation mode, the transmission quality of content data is made lower than that in the audio mode, whereby the two-way communication can be  
10 performed with a higher throughput. It is possible, therefore, to execute communication with the headset 20 in the communication environment suited to the mode of use of the headset 20, such as music reproduction or conversation.

15           The switching between the two communication modes, i.e. the audio mode and conversation mode, can be effected only by the key operation on the keyboard 13, by defining the combinations of keys corresponding to the audio mode and the conversation mode. The input  
20 device for designating the communication mode to be executed is not limited to the keyboard or pointing device. A dedicated operation button for designating the communication mode may be used.

25           The same compression-encoding scheme may be used for both the audio mode and conversation mode. In this case, too, the value of sampling frequency for sampling audio data to be transmitted is made lower in the

conversation mode than in the audio mode, whereby a sufficiently high throughput can be obtained in the conversation mode.

5       The values of parameter information corresponding to each of the audio mode and conversation mode can be altered by the user operation. Needless to say, two sampling frequency values, that is, a high sampling frequency value and a low sampling frequency value, may be prepared for each communication mode, and the user  
10       may operate the input device to automatically switch the value of sampling frequency to be used. Thereby, even in the same communication mode, the bit rate of an audio data stream to be transmitted can be altered.

15       All the communication control processes associated with the audio mode and conversation mode are realized by the computer program. Therefore, the same advantages as with the present embodiment can easily be obtained by simply installing the computer program in a computer with a wireless communication function,  
20       using a computer-readable storage medium storing this computer program.

25       Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the



spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.